S. J. B.

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

Published at

LOYOLA COLLEGE

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Bulletin of American Association of Jesuit Scientists

EASTERN STATES DIVISION

VOL. XV — MARCH, 1938 — No. 3

SCIENCE AND PHILOSOPHY

SCIENCE, METAPHYSICS AND HUMAN KNOWLEDGE

REV. JOSEPH F. BEGLAN, S. J.

The present writer hopes that he is not going too far afield from the province of this review in suggesting to its readers the necessity of a correlation between the physical, the social, and the philosophical sciences in the basic structure of all human knowledge. That these sciences are distinct in their proximate contents as well as in the proper viewpoint of each all readily admit. But all equally agree that there is a borderland, where scientist and philosopher meet to study the intrinsic constitution of matter, as biologist and psychologist both investigate the nature of life. Yet, in addition to this, it must be said that since all truth is unitary in its primal source and in its ultimate end, which is God, every investigator of truth must have a basic concept of its constituent elements, if he is to harmonize his findings with those of his collaborators in other fields. The scientist is interested primarily in the facts of his experience and the immediate laws which govern them. The philosopher has a broader and a deeper field. With the whole cosmos as his laboratory he tries to interpret its very nature to men. While in no sense neglecting evident facts, he is most of all concerned with those universal and necessary principles, which express the fundamental relationships among these facts. Thus the fact finding of science and the metaphysical reasoning of philosophy are the twin pillars of that temple of truth which we call human knowledge. So it cannot be said simply, *"let the philosopher keep to his cosmos and his metaphysics, and the scientist to his laboratory and his scopes."* Each has a right to a hearing in the field of his specialty, but each must borrow from the other if his search for real knowledge is to end in anything but the invention of a chimera. Segregate physical fact from metaphysical principle and at once you are on the highroad to one of two equal absurdities, crass materialism or fanciful pantheism.

It may not be inappropriate, for clearness' sake, to formulate a definition of fact and of principle. In brief, a fact is an existing thing an actual, not merely a possible, being. It may be a stone, a flower, a dog, a man, or God Himself. It may also be a thought conceived in my mind, a movement of my hand, the color of a falling leaf. I may know it directly with sense perception as I see this

white paper or I may gather its existence by inference, either with the help of scientific apparatus, as the physicist comes to know the existence of electrons, or with unaided human reason, as the philosopher discerns the human soul as the source of vital actions. I may with my intellect conceive a group of facts as one, as the United States or the cosmos itself, but here my reason tells me that the unity I predicate of them is logical not physical. But in any and all cases, a fact is anything which has actual existence, a being which in its existent state is independent of any created mind which contemplates it.

But here we are confronted with a difficulty. If a thought may be a fact, and yet is certainly only a mental thing, it would seem that our definition limps decidedly. How can a thought, in order to be a fact, be independent of the mind? However, here we may, in fact we must, distinguish between the contemplative and the productive aspects of the mind's powers. A thought, and here the term is used synonymously with any mental act, has a twofold character. It is both existent in the mind and representative of an object. As a mental existent, its genetic character is negligible to an epistemologist though of very definite interest to a psychologist. But the philosopher who ponders the knowledge problem centers his attention chiefly upon what his thoughts represent. Are they true? Do they square with reality or not? So that, while a thought may in its existential state be a fact, and as a product of my mind have its brief share of reality, independently of any further contemplation of my mind or any other's its importance lies rather in its representative value than in the contingency of its existence in someone's mind.

Now all of these facts that I observe, whether mental or extramental, are individual as well as real. The universal "a parte rei" is only a figment of the Platonic imagination. And all facts but one, that is God Himself. are events, things that have come, ultimately through His Omnipotence, from a state of pure potency into that of actual being. God alone is necessary, all else are contingent things.

Relegating the Cartesian theory of innate ideas to the limbo of irrational extravaganzas, it is obvious that there is only one approach to factual knowledge, and that is by experience. Moreover, if our knowledge, scientific or philosophical, is to have the stamp of truth, every metaphysical principle, every analytical proposition, must have a nucleus of fact. Hence the very starting point of all real knowledge is some datum of experience, the initial contact of the mind with the existing world.

Yet, as we have implied, the mere mental assimilation of facts alone does not, nor can it, constitute the sum total either of science or philosophy. There is an organism of truth, a systematized body of knowledge, as real, though in an analogical sense, as the organism

of the living person. Neither scientist nor philosopher can be satisfied with knowing what is here or there in the universe, what happens to be now or then. Both in their respective fields seek to learn what is universal, what is everywhere and always, what must be by the very laws of reality. Individual facts must be classified, correlated or subordinated to one another and unified by the principles of being, which the mind may discover but does not wholly invent. Here indeed is the crux of the whole knowledge problem. How derive the universal and the necessary from the individual and the contingent? Metaphysics alone supplies the key to this seeming mystery of thought. The human intellect is gifted with a peculiar native insight into the nature and essence of things. It readily discerns, at least in the broad outlines of the world of experience, the universal and the necessary latent in the individual and the contingent.

In any existing thing that falls under our experience, be it substance or accident, we know it to be "something", a real being, and by the very cogency of its own evidence we are forced to judge that it is not "nothing", nor can it in its existent state conceivably be or be called "nothing". True, through some adverse forces, it may change its present form or pass out of existence in time, but we cannot consciously couple its present state in any propositional form with mere "nothingness". From this existing being of experience the human intellect abstracts the single "note" of "being", and, contemplating it thus in this timeless, spaceless, and non-dimensional form of abstraction, sees by the very evidence of "being as such" that it is unalterably opposed to its own contradictory, "non-being", which is the most fundamental of the metaphysical principles, the Principle of Contradiction, "A thing cannot be and not be at the same time", or "Between being and non-being there is a necessary and universal opposition". The very denial of this statement is its own assertion. Obviously being self-evident it neither can be nor need be demonstrated. The proof of its validity is entirely indirect, contained within the core of all reality and all knowledge. Though it may be and has been denied in human language, it is undeniable in human thought, for universal skepticism as a mental state is impossible. This basic law both of thought and thing is not as such empirical but analytical. It may be endlessly illustrated in individual experience but it needs no verification in such data. Here we have the paradox of the universal and the necessary existing fundamentally within the individual and the contingent.

Here too we have the basis of the difference between fact and principle. For the Principle of Contradiction, though an undeniable truth, is in no sense a "fact". In its formal state, that is, as a law both of thought and thing, it has neither actual existence nor individuality apart from the conceiving mind. It may be, and often is, expressed in the mental act of judgment or in the propositional

form of speech, yet these expressions do not constitute the principle itself, for it is basically independent of any created individual's mind or action. Even these acts, as we have said above, are, as such, contingent facts. None of them, individually or collectively, have that necessity of being, which is the property of this most fundamental principle. Its ultimate root and source is the infinite essence of God, "Actus Purissimus", who, as the plentitude of all being, can never be "non-being". God, who calls Himself "I who am", is the Primal Fact, who gives to this principle its ontological necessity and universal predicability to all things that are. They "are", actually and potentially, only because He first "IS". Hence we may formulate our definition of "principle", that is, logical principle as opposed to the physical principles of life and action. A logical principle is an abstract truth, universal and necessary in its application to created things, incapable of any formal actual existence save in the mind, yet independent in reality of such formulation by created intellectual acts, since its basis is the essence of all that is. From such principles other truths flow by the synthesis of these with known facts, and so science and philosophy grow.

In addition to the Principle of Contradiction there are three other metaphysical principles of scarcely less importance to an adequate philosophy of knowledge. They are too well known to the readers of this review to need any extensive elaboration here. But a brief mention of them and an indication of their importance in the knowledge problem may not be out of place. The concept of being itself includes its own differentiation from non-being, yet that which differentiates it must be ultimately something real and actual. Hence the Principle of Sufficient Reason, "Every being has some sufficient reason for itself". Applying this to the universal phenomenon of change in the world, we derive the notion of contingency, which implies the Principle of Causality, "Every contingent being has some efficient cause of its existence". The fourth is the Principle of Final Causality. As St. Thomas in the Contra Gentiles (English Translation by the Dominican Fathers, The Third Book, Chapter 2) has it: "Every agent acts for an end". Here he gives seven arguments to show that the notion of end or purpose is implicit in the concept of efficient action. We quote here the seventh and last argument of Aquinas. "Were an agent not to act for a definite effect, all effects would be indifferent to it. Now that which is indifferent to many effects does not produce one rather than another: wherefore from that which is indifferent to either of two effects, no effect results, unless it be determined by something to one of them. Hence it would be impossible for it to act. Therefore every agent tends to some definite effect, which is called its end". (Op. Cit. p. 6.) The application of this law of finality to secondary agents which at least apparently, operate casually, as in the case of earthquakes, tidal waves and such

like misfortunes which bring havoc and destruction both to nature and to men opens up the whole question of the problem of evil. This indeed is insoluble apart from philosophical and theological principles. Yet such chance effects, far from being opposed to teleology, are rather a confirmation of this principle. For they are due to the clash of mutually antagonistic forces, whether in man or in the world outside man, and each is following the fundamental law of its own individual being, acting for its proximate end, which is self-preservation and self-development. Yet each proximate end is subordinate to higher and more universal ends which it must serve, and all are regulated under the directive and permissive providence of God to accomplish the ultimate design of the universe which He first created. To the materialist all this sounds like the most unintelligible mysticism, without a shred of evidence in objective nature, but to the Catholic teacher, scientist or philosopher, it is the veriest deliverance of reason, synthesizing fact with metaphysical principle, as well as of faith in a divine revelation.

The fundamental character of the Principle of contradiction, in its application to all knowledge, has been discussed above. It underlies every doctrine of science and philosophy, every hypothesis, theory, law, that has been formulated by students of nature. It is only by assiduous attention to its primary implication that truth cannot be contradictory to itself that we can achieve a proper harmony among the different departments of human knowledge. Neither scientist nor philosopher is content merely to catalogue the facts of the universe. It is the province of both to investigate the relations between things, to discover their objective reasons, the causes of all the phenomena of the senses. In every real event its objective reason is some cause. Herein lies the importance of the metaphysical principles of Sufficient Reason and of Causality. But the effect must of its nature be proportioned to its cause. The materialists in the academic world of science and philosophy, with their irrational postulates of the genetic continuity of matter and its own self-sufficiency of existence, become, by their utter disregard for the principles of reason, the most unprincipled of men. With a background that consists only of Empiricism, Sensism, Positivism and Naturalism, they are trying to build a temple of knowledge founded only on the shifting sands of ever changing phenomena. And so they blind themselves to the evidence of the universal, the eternal and the immutable in nature and nature's First Cause, who alone has complete adequacy and activity of being. The "many" in the universe are inevitably reducible to the "One", but not by genetic descent. Creation, and Creation alone, is the answer to the mind's quest for ultimate unity. The scientist as such in his own field is not interested in teleology. Engaged as he is in expounding truth, verifiable in experience, he is not concerned with the hidden purposes of nature, speaking however

eloquently to the philosopher and the theologian of nature's God. Yet in his character of Catholic teacher, set upon preaching the gospel of God, even when the text is the world of matter, he can never be far away from ultimate final causes.

We have spoken of God with His attributes as the Primal Fact. Though not first in the order of our human knowledge He is first in the order of reality. There are two other fundamental facts, or rather sets of facts, of vast importance. They are the existence of this real material universe, composed ultimately of substance and accidents, and the existence of human minds endowed with a native capacity to know with certitude. This complexus of Three Fundamental Facts and Four Metaphysical Principles forms the framework of all knowledge whether philosophical or scientific. Into this must fit every demonstrable truth in the order of nature. Every hypothesis, theory, or supposed law of thought or action, which does not ultimately regard these fundamental truths, is thereby false. Man's knowledge may and does progress within the circumference of this sphere but by the nature of Truth and Reality itself can neither transcend nor contravene it.

Whatever the trend be among the moderns to relinquish anything like final certitude and to be content with balancing probabilities in solving scientific or philosophical problems, it is objectively evident that the very notion of probability implies the general capacity of the mind to know some truths with absolute certitude. The very distinction that is made between probability and certitude implies that we know what each is, and that we have a criterion to separate them within the mind and without. And so the commonly accepted principle of all materialistic schools of thought that we can never say the last word about anything is patently false. We need not await the final summons of the world to judgment before we may say: "I know", instead of "I think". Undoubtedly science and philosophy must and does make progress in this human march of time. No one age knows all the possible facts of experience nor all of their underlying laws. Much of what is now regarded as demonstrated in various fields of inquiry may at some later date prove only imperfectly known, and need recasting in the light of further experimental data. But it still unequivocably remains that there are certain fundamental truths that are timeless and spaceless, and so are independent of human progress or regress in thought.

Hence science, just as philosophy, must be constructed upon the basis of these fundamental truths. The application of these to other evident facts of experience gives us some criterion to judge what is immutably true and certain, and what may be only probable, an approach to truth. Here the present writer hastens to say that he does not regard these fundamentals as the only certain doctrines of human thought. Far from it. He knows that there are many

more in philosophy, but it would tax the already overwrought patience of our readers to define them here. He is conscious too that it would be an unwarranted presumption in him to try to mark off what is certain and what probable in the well-developed body of scientific knowledge. There is indeed here material enough for another paper.

It might well seem to some that the import of this essay is to make philosophy teachers out of all our scientists, but nothing is farther from the writer's mind. If one thing definite has been said it is a plea for a synthesis of all our knowledge according to the basic truths of Scholastic Metaphysics. The philosopher and the scientist must work together. Each needs the other. None is better equipped than the scientist for fact-finding in nature's field. His is the technical training and the specialized apparatus to explore the microcosms and the macrocosms of the material universe. His also is the slow, patient, and persistent laboratory method of repeated experimentation to unearth the golden ore of truth from hidden vaults and separate it from the dross of pseudoscience. To him the philosopher must go for the relevant facts in his own field which are not evident by simple observation. Yet he approaches the philosopher's realm, when on the basis of his research he begins to interpret nature's activities by formulating hypotheses, theories, and empirical laws, which are of vast importance in human life. Here he must be guided by a basic metaphysics. The philosopher himself, supplied with the facts of observation, natural or scientific, and with the scientific principles which are partly factual, partly rational, must fit these into his fundamental framework and so fill out the dim outline of human knowledge, until its features approach, however distantly, the image of God, in whom all is made.

The body of human knowledge is an organism, analogous to the living person of the human individual. The raw materials of experience are assimilated by the patient and accurate observation of the universe to form the mental cells of all learning, which are the facts ascertained. These increase with time, as our experience grows, but that which gives them organization and vitality to thrive for human welfare is the fourfold Principle of Contradiction, Sufficient Reason, Causality, and Finality. Remove these and the result is disorganization of knowledge, which is death to the academic soul of man. Almost without exception outside the sphere of Catholic thought human knowledge is disorganized, chaotic. It is without the guidance of reason or revelation, though here and there we see some signs of the beginning of a return to scholastic principles. The salvation of the world of thought lies not in science alone, nor in philosophy alone, but in a rational synthesis of both under the aegis of the Church, the infallible custodian of divine revelation.

CHEMISTRY

A YEAR'S ADVANCE IN CHEMISTRY

Rev. Richard B. Schmitt, S. J.

The coming of the new year again calls for a brief retrospect of the progress of chemistry, which steadily marches on to unending ramifications of sub-atomic structure, vitamins, hormones, transmutation, molecular distillations, catalyses and innumerable organic syntheses, biological and industrial.

Isotopes still play a prominent part in chemical research. We might mention the continuation of the work of Dr. Harold C. Urey, discoverer of hydrogen 2 and hydrogen 3, who recently put on display at Indianapolis sizable samples of water which have an increased concentration of oxygen 18, approximately four and one-half times that of natural water. He also prepared goodly amounts of ammonium chloride whose nitrogen contains two and one-half per cent nitrogen 15, being six and one-half fold increased concentration of this isotope. These samples were prepared by the distillation of water, and by chemical exchange reaction between ammonium ions and ammonia gas. Dr. Urey and Bremer succeeded in partly separating the isotopes of potassium 39 and 41. Drs. W. R. Smythe and A. Hemmendinger announced a third isotope of potassium with an atomic weight of 40; this variety was made radioactive and it held this activity for eleven minutes.

Drs. Milton G. White, Malcolm C. and William J. Henderson, and Louis N. Ridenour converted chlorine atoms from sodium chloride first into potassium and then into argon.

Isotopes have found a very interesting and important use in biochemistry, since they were used to trace the fates of food materials in metabolism. In other words, when these isotopes are mixed with meat, eggs and other forms of proteins, their reactions may be traced in the various tissues of the body. Deuterium compounds have been used for this purpose, and the isolation of the heavy isotopes of nitrogen provides another valuable tool for this type of research.

Vitamin A has been isolated as a pure crystal. Deficiency of this vitamin is held responsible for night blindness, the cause of many automobile accidents. A new male hormone was isolated at Pennsylvania State College. The enzyme catalase was prepared in

pure crystalline form. Ten amino acids have been found to be necessary for the health and growth of the human body.

The discovery of a new vitamin-like compound was announced by Albert von Szent—Györgyi, of Hungary, the 1937 Nobel Prize winner for physiology and medicine. The new vitamin was designated vitamin P, meaning permeability. This vitamin is closely related to vitamin C in plants.

The precise reactions of chlorophyll are still unsolved, although many advances were reported. It was supposed that chlorophyll was the direct product of sunlight acting on the carbon dioxide of the air. However, Dr. Ondess L. Inman, Director of the C. F. Kettering Foundation reported in no uncertain terms that there is something in the plant besides chlorophyll which must be investigated, something which plays the major role in imprisoning sunlight and making plants grow by the process of photosynthesis. A total of seventy compounds closely related to chlorophyll have now been synthesized.

A new process of distillation is now used for producing new compounds and for the reparation of complicated materials; this process is called molecular distillation. The production of Vitamin A concentrates by high vacuum molecular distillation of fish liver oils was put on a commercial basis by the Eastman Kodak Co., in cooperation with General Mills, Inc., and the product, free from fish characteristics, is being used to fortify various foods.

There is another claim for the discovery of element 87, the element between radon and radium, by Horia Hulubei, a Rumanian physicist, living in Paris; it was named Mavodium.

Methylcholanthrene obtained from bile acids is a cancer producing compound. This material was synthesized by Dr. Louis F. Fieser and his associates; they claim to have produced twenty-two cancer producing substances.

Last year Canada produced fifty grams of radium salt. In England, a new liquified petroleum gas: propagas was put on the market.

The progress of industrial chemistry is phenomenal. In the United States alone, industrial research expended over one hundred millions of dollars. Consequently, there are hundreds of new products now available for industry and for commercial use. It would be impossible to make a complete list of all of these products, however just a few may be mentioned here. Heat-treated cast irons were used for gears and other machine parts previously made from steel. Silver bearings were employed in high-power aviation engines. Specially treated lubricants enabled much higher bearing pressures. High octane anti-knock gasoline at lower costs promised increased fuel efficiency for airplanes. The manufacture of carbon dioxide filled incandescent lamps was perfected.

Other new products are: new adhesives from synthetic resins;

cellulose sponge; new pigment dyes; novel emulsifying agents; triton B, an organic base said to be as strong as sodium hydroxide; plastic wood; rapid drying inks; morpholine, a new solvent; tergitols, compounds for use as wetting agents; tetraphosphoric acid; a titanium silicate pigment; electrolytically colored metals; and synthetic ascorbic acid (vitamin C) prepared from sarbitol, which in turn is made from corn sugar. Sweet potatoes are being grown to yield starch commercially and of a grade similar to that from tapioca and cassava; and southern farm lands are being planted with this vegetable to meet the demands of starch factories.

Dr. McAllister of the Smithsonian Institute developed a spectrophotographic method for measuring carbon dioxide in five seconds, to obtain accuracy in readings, which can be made every thirty seconds. As little as one part in a million parts of air can be detected; and the speed is such that the metabolic ratio of each breath of an animal can be determined.

We have enumerated only a few of the new discoveries of the past year in the field of chemistry. A great many more are enumerated in the literature.

> *"Experience is by industry achieved*
> *And perfected by the swift course of time."*
> Two Gentlemen of Verona, I, 3, 23.

MATHEMATICS

DIOPHANTINE EQUATIONS*

Rev. Edward C. Phillips, S.J.

Diophantus was an Alexandrian mathematician who flourished most probably in the second half of the fourth century of our era (f.cir. 360 A.D.). His chief work was the "Arithmetica" of which a considerable portion is extant. He differs greatly in his methods from all previous Greek mathematicians who were essentially geometricians; Diophantus used, and is credited with the invention of, the algebraic method introducing and using with great skill literal expressions and signs for arithmetical quantities and operations, and is therefore called the Father of Algebra.

Many of the problems proposed and solved by Diophantus in his Arithmetica lead to equations containing a greater number of unknowns (or variables) than the number of algebraic conditions imposed by the problems themselves, and hence could not be solved uniquely: such equations or systems of equations are called "Indeterminate" or "Diophantine". In order to secure determinate values for the variables or unknowns some further condition or conditions must be imposed; in the Diophantine Analysis the most usual condition is that the equations are to be solved for integral or at least rational values. For the purpose of this paper, which does not make any claim whatever to being exhaustive, I will use the restricted definition given by Prof. J. M. A. Young in the chapter on The Theory of Numbers contained in the book he edited under the title of "Monographs on Modern Mathematics". His definition is:

> "An equation in two or more unknowns whose values are to be integrals is called a Diophantine or Indeterminate Equation."

Diophantus himself was generally satisfied by imposing the condition that the admissible values should be rational and positive. Since we require that the admissible values are to be integers and positive, our restriction is more severe: moreover we further restrict our problems to equations of the first degree in the unknowns, whilst those treated by Diophantus usually involved the squares or even the cubes of the unknowns. The type of equation then with which we are

* A paper presented at the Sixteenth Annual Meeting of the Association, Fordham University, August 16, 1937.

to deal is $ax+by=c$; wherein all the letters represent positive integers. There may of course be more than two variables, or rather unknowns involved.

Such an equation, e.g.

$$3x+7y=13$$

has an unlimited number of possible solutions. Give x any value and we can find the corresponding value of y satisfying the given relation: in fact you will doubtless recognize the equation as that of a straight line, x and y be the coordinates of any of the limitless number of points on the line. But let us restrict the equation by the condition that x and y must be positive integers, and we see at once that y cannot be greater than unity, since if it were 2, the second term would already be greater than 13 and hence x would have to be negative. We must therefore put y equal to unity, whence we find

$$3x=13-7 \text{ or } 6 \text{ and hence}$$
$$x=2$$

so that the sole solution is $x=2$; $y=1$.

I hope that the idea of a Diophantine Equation is now clear. So let us pass on to the simple applications to which this paper is devoted.

For these applications I have chosen a class of numerical puzzles often met with in the puzzle columns of modern popular scientific or pseudo-scientific magazines, but which have engaged the serious attention of mathematicians for centuries past. They constitute a portion of the Theory of Numbers and may be called Problems in the partition of numbers. We may pick out at random one such puzzle or problem:

Farmer Jones bought at an auction sale some horses, cows and pigs numbering in all one hundred head. For each horse he paid four dollars; for each cow two dollars and for each pig fifty cents; and the whole cost was just one hundred dollars. Quaeritur: How many of each kind did he buy?

How will the ordinary reader of such magazines, the puzzle fan, go about solving this puzzle? The same way, I imagine, as the 16th. Century Italian mathematician Tartaglia worked out more complicated problems of the same nature, namely by the age-old method of trial and error. Well, we happen to drop into the country grocery store shortly after the sale, and a number of farmers are gathered together there chatting with Smith the grocer man, as often happens in the country, and they are discussing the sale and show some curiosity as to just how many head Farmer Jones did buy. Farmer Black and Farmer White try to satisfy their curiosity by figuring out the problem each in his own way. Putting it down on paper to help their wits the problem looks like this:

$H+C+P$ totals up 100

and $4H+2C+P/2$ totals 100

Farmer Black says to himself: "The horses cost most and so there would be fewest of these, so I'll begin with horses and suppose he bought one horse: that would cost $4 and leave $96 with which to buy if possible 99 cows and pigs. The cows cost more than the pigs, so let us suppose he bought one third of cows and two thirds of pigs: that would mean 33 cows costing $66 and 66 pigs costing $33 and that makes $99 which is $3 to much: so try fewer cows, say 31 cows and 68 pigs; they would cost $62 plus $34 or just the required $96." And he shouts out: "Hurrah, I have the solution!"

In the meantime Farmer White, who likes big numbers, started off at the other end saying to himself: "Since the pigs are cheapest, Jones must have bought most of those: I'll try 90 pigs: they would cost $45 and leave $55 to buy, if possible, 10 horses and cows. But that won't do, because both cows and horses cost even numbers of dollars, and moreover 10 horses would only cost $40. Let me see how 80 pigs would fit in. They would cost $40 leaving $60 to buy 20 horses and cows: now one horse plus one cow cost $6 and so 10 horses plus 10 cows would cost exactly the required $60, making the total $100." And he shouts out at the same moment as Farmer Black: "Hurrah, I have the solution!"

Smith, the Grocer, has been waiting for the results and chimes in: "Well both of you are quick at figures; and now tell me how many horses, cows and pigs did Farmer Jones buy."

Black says: "1 horse, 31 cows, 68 pigs!" and at the same time

White says: "10 horses, 10 cows, 80 pigs!"

Then they begin to wrangle over the conflicting solutions, but Smith not wishing any quarrel in his store says: "Now, boys, don't get hot: it would look as if one or both of you made a slip somewhere in your figuring. But here comes Jones himself; let us ask him. He's an honest man and will tell us the truth. Jones, how about that sale: how many horses, cows and pigs did you buy?"

Jones answers: "Well, I needed horses a plenty to run my big farm, so I bought 13 horses, 3 cows and 84 pigs: and a right good bargain I got, paying only $100 for the lot of them.

So much for the farmers: and now I ask you as mathematicians who was right and who was wrong, and why? Well Jones, being an honest man, told the truth and therefore he was right, and he alone. We can check his statement and find that $13+3+84=100$, and $13\times4+3\times2+84\times1/2=52+6+42=100$. But then as far as figures go, Black and White gave answers that measure up to this same check. And in fact both were wrong, only because they said that they had found **the** solution, when they should have said that they had each found **a** solution (which happened not to coincide with actual facts of the purchase). This teaches us that mathematically the problem does not admit of a single, unique solution but that there are a number of solutions, three of which have been given above.

How many, if any, more solutions does the problem admit? We could go on by the trial and error method and finally discover all the possible solutions: but this is not only wasteful of much time but is also unsatisfactory from a scientific point of view: we desire a definite algebraic method which will show us by a single algebraic statement, if possible, all the admissible solutions. And I was urged on to present this paper partly because there seems to be a fairly widespread opinion that such problems cannot be solved by algebra: that is an error and in what follows I will strive to set forth a simple and complete algebraic solution of all such problems. It may be helpful to illustrate the method by taking as a sample the puzzle or problem proposed above. Using our ordinary notation for unknowns we state the two algebraic conditions set forth in the problem thus:

(1) $$x+y+z=100$$

(2) $$4x+2y+z/2=100$$

Having two equations we may eliminate one of the unknowns and get a new equation involving only two of them. Multiply (2) by 2 in order to get rid of the fractional term, and then subtract (1):

(3) $$8x+4y+z=200$$

$$x+y+z=100$$

(4) $$7x+3y=100$$

Every problem of the above type leads to an equation of this form, namely a single equation of the first degree in two unknowns which must be solved **for positive integral** values of the unknowns. There are a number of methods for solving such an equation: Young in the place referred to above shows that every such equation can be solved by the use Congruences and Continued Fractions; but there is a way which seems to me simpler and more direct, and easily learned by any boy who knows a little algebra. I do not claim originality for the method though I have not seen it in any of the few books I have read on the subject. Proceed as follows:

Solve equation (4) for x, and reduce the expression thus found to its integral part (i.e. the quotient obtained by dividing the numerator by the denominator) and its fractional part (i.e. the remainder).

(5) $$x=(100-3y)/7=14+(2-3y)/7.$$

Now since x is to be an integer and also y, it follows that the fractional expression thus obtained must be in fact an integer, i.e. the value of y must be such that the numerator will be a multiply of 7. So let us equate the fractional expression to an arbitrary constant r, which must itself be an integer either positive or negative.

(6) $$(2-3y)/7=r \quad \text{or} \quad 2-3y=7r.$$

This is another equation of the same form as (4) and we treat it in the same way:

(7) $$3y=2-7r;$$

$$\text{or} \quad y=-2r+(2-r)/3.$$

The fractional expression here must also be in reality an integer, so we equate it to another arbitrary constant integer, say n.

(8) $(2—r)/3=n$, and hence $2—r=3n$ whence we have

(9) $r=2—3n$.

The fractional expressions have thus been reduced to pure integers. We now work backwards so as to get purely integral expressions for x and y in terms of the arbitrary auxiliary constant n. Thus putting the value of r found in our last equation into equation (7) we get $3y=2—14+21n$ and therefore $y=—4+7n$.

We put this value of y in (5) and get the integral expression for x.

(10) $x=(100+12—21n)/7=16—3n$.

Finally we put these values of x and y in (1) and solve for the integral value of z:

(11) $z=100—x—y=100—16+3n+4—7n=4n$.

Collecting these values together we now have the complete solution:

(12) $x=16—3n$ $\quad 4x=64—12n$

$y=7n—4$ $\quad 2y=14n—8$

$z=88—4n$ $\quad z/2=44—2n$

From the form of y it is clear that n must be a positive integer, otherwise y would be negative; also from the form of x it is clear that n cannot be greater than 5, otherwise x would be negative. The only possible values of the auxiliary constant n are therefore 1, 2, 3, 4, and 5. Hence there are five and only five solutions, which we here give in tabular form:

n	x	y	z	Sum	4x	2y	z/2	Sum
1	13	3	84	100	52	6	42	100 (Farmer Jones' actual purchase)
2	10	10	80	100	40	20	40	100 (Farmer White's solution)
3	7	17	76	100	28	34	38	100
4	4	24	72	100	16	48	36	100
5	1	31	68	100	4	62	34	100 (Farmer Black's solution)

The method given above is perfectly general. But what if we never come to a fully integral expression for our auxiliary constant? This would prove that the problem as proposed has no solution. Moreover it should be noted that as the denominators of the succeeding fractional remainders are necessarily each smaller than the preceding one, we soon come to the end of the line of equations and get a solution similar to that in equation (9) or else we come to an equation of the form.

(13) $r=n+a/b$, where a and b are pure numbers prime to each other. Now as r, supposedly an integer, cannot be equal to the sum of an integer and an irreducible fraction, such an equation shows that there is no possible value of y which would make the left hand member of equation (6) an integer. And if we put down any numbers at random in our original puzzle it is probable that in many cases there would be no solution at all: so it would not be fair to give an

amateur a puzzle of this kind before we have tested it to see if there is any solution.

Perhaps someone may be saying to himself: "Well that method is alright, but it looks almost as complicated as the method by trial and error: see how easily those farmers got an answer." To this I might reply that each of them got **an** answer but neither of them suspected that there was a different answer, and probably they would never have been able to tell just how many possible answers there are. However when the numbers involved are small, one could with patience run through all the possible combinations and pick out all the answers. But let us take a more complicated puzzle or problem, which can arise in practice, and I do not think anyone would dare attempt to find all the solutions by the trial and error method.

Problem.—A transcontinental airway transportation company carries passengers from New York to three terminals: Chicago, Denver and San Francisco; the passenger fares and the total number of passengers carried during a certain period of six months were as follows:

Fare to Chicago \$44.95.
" to Denver \$98.55.
" to San Francisco \$149.95.

Total amount taken in was \$1,346,577.70.

Total number of passengers carried 14,298.

Question: How many passengers were carried to each of the terminals? A fire in the Auditor's office destroyed the records of individual bookings and the only available information beyond what is given above is the testimony of the New York ticket agents that the greatest number of passengers went only as far as Chicago and the fewest number went on through to San Francisco.

That seems a pretty hard question for an Auditor, with nothing but a pile of ashes on his hands. to answer. But let him call in an Algebraist and the task becomes relatively simple with the help of the method out lined above. Let us apply it:

(1) $149.95x+98.55y+44.95z=1,346,557.70$

(2) $x+y+z=14,298$

If we multiply (2) by 44.95 and subtract the product from (1) we get:

(3) $105.00x+53.60y=703,862.60$

Let us multiply (3) by 5 so as to rid it of the fractional parts of a dollar:

(4) $525x+268y=3,519,313$

This is the equation we are to treat as we did the equation $7x+3y=100$ in the previous example. Hence:

(5) $x=6703+2(119-134y)/525=6703+2r$

(6) $y=(119-525r)/134=1-4r+(11r-15)/134=1-4r+s$

(7) $r=(134s+15)/11=12s+1+(2s+4)/11=12s+1+t$

$$(8) \qquad s=(11t-4)/2=5t-2+t/2=5t-2+n$$

$$(9) \qquad t=2n$$

We now substitute in reverse order:

$$(8^{1}) \qquad s=11n-2$$

$$(7^{1}) \qquad r=134n-23$$

$$(5^{1}) \qquad x=6703+268n-46=6657+268n$$

$$(6^{1}) \qquad y=1-536n+92+11n-2=91-525n$$

Therefore $z=14{,}298-6657-268n-91+525n=7550+257n$.

Collecting our results in tabular form we have; (after changing the sign of n for convenience):

$$(10) \qquad \begin{array}{ll} x=6657-268n & 149.95x=998{,}217.15-40{,}186.60n \\ y=\ \ 91+525n & 98.55y=\ \ 8{,}968.05+51{,}738.75n \\ z=7550-257n & 44.95z=339{,}372.50-11{,}552.15n \\ \hline \text{Sum}=14{,}298 & \text{Sum}=1{,}346.557.70 \end{array}$$

From the value of y we see that n must be zero or positive, otherwise y would be negative.

From the value of x we see that n must be less than 25, otherwise x would be negative.

Hence there are 25 integral solutions corresponding to the twenty-five values of n, namely 0, 1, 2 etc. up to 24.

However there was one more item of information, which imposes one more condition, namely that x is less than y, and y less than z. Let us apply this condition and find out which of the values of n, and therefore which of the 25 solutions, are admissible.

We have

$$\begin{array}{lll} 6657-268n<91+525n & \text{therefore} & 793n>6566 \text{ or } n>8 \\ 91+525n<7550-257n & \text{"} & 782n<7659 \text{ or } n<10 \end{array}$$

Now the only number greater than 8 and less than 10 is 9: therefore under the actual conditions given, there is only one solution, the one given by putting n equal to 9 in the equations (10) namely

$$\begin{array}{ll} x=4245 & 149.95x=636{,}537.75 \\ y=4816 & 98.55y=474{,}616.80 \\ z=5237 & 44.95z=235{,}403.15 \\ \hline \text{Sum}>14{,}298 & \text{Sum}=1{,}346{,}557.70 \end{array}$$

If one were to go about the solution blindly by the trial and error method, it would most likely take months, probably years of work before coming to a final and sure solution. The advantage, as well as the intellectual satisfaction, derived from a formal algebraic solution, complete, compact and graced with mathematical certitude, seems evident.

The Italian mathematician Tartaglia (Niccola Fontana, "The Stammerer", born at Brescia 1500; died at Venice, December 14, 1559: published his "Arithmetic" in 1556 and his "Treatise on Numbers"

in 1560) interested himself in these problems and extended his researches to those involving four or five unknowns with only two equations of conditions to determine the solutions. Such problems offer questions of interest to the Algebraist, and we will consider here a method which will enable us to get systematically all the solutions of any given problem. Let us take one of the particular problems proposed and partially solved by Tartaglia in his "Arithmetic"; it may represent the bill of a party of men, women, boys and girls who went to a restaurant (an inn) to buy food: I will not give the verbal statement but start at once with the algebraic equations involved:

(1) $x+y+z+w=100$ (2) $3x+y+z/3+w/2=100$

From these conditions we are asked to determine how many men, women, boys and girls constituted the party.

Tartaglia gives as his solution: $x=19$ (men), $y=22$ (women), $z=51$ (boys) and $w=8$ (girls). He adds that he found this solution by the method of trial and error and did not know of any general algebraic method for obtaining solutions for this and similar problems.

The French mathematicians Bachet (Claude-Gaspar Bachet, Sieur de Méziriac, born 1581, died 1638; published his "Problemes plaisants et délectables qui se font par les nombres", 1st. edition 1612 and 2nd. edition 1624) took up the problem where Tartaglia had left off and developed an algebraic method of systemmatically obtaining all possible solutions by successive consideration of the **limiting values** of each of the unknowns but does not give a single algebraic expression or statement for the general solution. He tells us that there are 226 solutions in all, but for fear of exhausting the patience of his readers and "still more of the printer", he enumerates only the 18 solutions in which x has the value 19 found by Tartaglia.

We may however proceed as in the case of three unknowns but we will have to introduce now two auxiliary arbitrary constants, say, m and n instead of one. Perhaps the simplest way of doing this is to substitute one of these auxiliary constants for the first of the unknown thus putting $x=m$ and then proceed as in the previous case, solving for the other three unknowns. Let us apply this to Tartaglia's problem. First transfer x in the form of an assumed constant m, to the right-hand side of the equations: eliminate y and thus obtain a single equation in the two unknowns z and w which is to be solved for integral values in terms of another auxiliary constant n.

(3) $6y+6z+6w=600-6m$

(4) $6y+2z+3w=600-18m$

(5) $4z+3w=12m$

Solve for z in terms of the other quantities, getting:

(6) $z=3m-3w/4$.

As z, m and w are integers the last expression has to be an inte-

ger also, so we put it equal to an assumed constant 3n, or

(7) $w=4n$, whence it follows that

(8) $z=3m—3n$.

Substituting the above values of x, z and w in equation (1) we obtain the expression for y in terms of the assumed constants m and n, thus

(9) $y=100—x—z—w=100—m—3m+3n—4n=100—4m—n$.

Collecting these expressions into tabular form, we have the complete algebraic statement of the solution of the problem:

(10)

$x=m$	$3x=3m$
$y=100—4m—n$	$y=100—4m—n$
$z=3m—3n$	$z/3=m—n$
$w=4n$	$w/2=2n$
Sum=100	Sum=100

To complete the solution for determination of the individual numerical values, we seek the Limits between which the constants m and n may be chosen. Since all the unknowns must, by supposition, be positive integers it follows that m and n are positive integers, therefore neither of them can be less than 1.

From the expression $z=3(m—n)$, it follows that m is greater than n by at least one unit, otherwise z would be negative or zero; hence m must be at least 2, so as to be larger than n.

From the expression $y=100—4m—n$, we see that $4m+n$ must be less than 100, otherwise y would be zero or negative. Hence m must be less than $(100—n)/4$ or less than $25—n/4$; therefore upper limit of m is 24.

From the expression $y=100—4m—n$, we see that $4m+n$ must be less than 100, otherwise y would be zero or negative. Hence m must be less than $(100—n)/4$ or less than $25—n/4$; therefore the upper limit of m is 24.

Furthermore since m equals $n+1$ or more, $4m+n$ equals $4(n+1)+n$ or more; therefore $5n+4$ is less than 100, or 5n is less than 96; i.e. n is less than 20. Hence the upper limit of n is 19.

All the admissible solutions are therefore obtained by putting m equal successively to 2, 3, 4, etc, up to 24; and combining with each of these values of m those values of n included in the series 1, 2, etc. up to 19 which at the same time satisfy the two conditions that n is less than m and also less than 100—4m.

We give below, under each value of m, the highest value of n which satisfies these conditions; this number is at the same time the number of solutions in which x has the indicated value of m.

When m=	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
highest n=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	15	11	7	3

From this we see that the total number N of solutions is the sum of two arithmetical series, namely the series $1+2+3, \ldots$ up to 19, plus the series $3+7+11+15$. The sum of the first series is $19\times20/2$, or 190: the sum of the second series is 36, so that the total number of solutions is, as already quoted from Bachet,

$$N=226.$$

Proceeding with Tartaglia one step further, we may consider the case of five unknowns with only two equations of conditions. In this case there will have to be introduced three auxiliary arbitrary constants. We may note in passing that in general, when there are j unknowns with only k equations of condition, k being less than j, there will have to be introduced into the solution j—k arbitrary constants. Another way of stating this is to say that we will have to express the values of the j unknowns as functions of j—k of these same unknowns to which we then assign arbitrary positive integral values within the limits imposed by the condition that all of the functions, j in number, will remain positive integers.

Tartaglia's problem in five unknowns is stated thus:

(1) $\quad x+y+z+u+v=200$

(2) $\quad 12x+3y+z+u/2+v/3=200$

Bachet tells us that Tartaglia gloried in his success in finding a solution of this problem; Bachet then adds that he in turn expects his readers to be filled with wonder when he tells them that by his "infallible mathematical procedure founded on solid demonstration" he has discovered that this problem admits of 6639 integral solutions. Tartaglia's lone solution is

$x=6,\quad y=12,\quad z=34,\quad u=52,\quad v=96,$ Sum 200

$$72+36+34+26+32=200.$$

Bachet then gives, as samples, the 44 solutions in which x and y retain the values 6 and 12, and the other unknowns take all their corresponding admissible values. He does not however give any further details as to the application of his method of solution in this case, nor does he give any general algebraic statement of the solution though this is easily obtainable by the methods indicated above in the case of four unknowns. I will give as briefly as I can the derivation of the functional values referred to just above and the limits of these functions as well as of the arbitrary assumed constants. We note in the first place that v must be a multiple of 3, otherwise the left-hand member of equation (2) would not be integral. Likewise u must be a multiple of 2. We will assume the following relations:

(3) $\quad x=m \qquad y=n \qquad v=3p$

We then have the two following equations to determine the functional values of z and u:

(4) $\quad z+u=200-m-n-3p$

(5) $\quad z+u/2=200-12m-3n-p$ or (5') $2z+u=400-24m-6n-2p$

Subtracting (4) from (5') we have for z the expression

(6) $z=200-23m-5n+p$

Again, subtracting (5) from (4) and multiplying the result by 2, we have for u the expression

(7) $u=22m+4n-4p$

which we see contains, as it must, the factor 2.

Our solution is therefore:

	$x=m$	$12x=12m$
	$y=n$	$3y=\quad 3n$
(8)	$z=200-23m-5n+p$	$z=-23m-5n+200+p$
	$u=22m+4n-4p$	$u/2=11m+2n\quad -2p$
	$v=3p$	$v/3=\qquad p$
	Sum=200	Sum=200

To complete the solution so as to get the individual values of the integers satisfying the conditions, we wish to know the **Limits** of the constants m, n and p.

It is clear that the lower limit in each case is 1.

From the expression for z we conclude that

(9) $p>23m+5n-200$ (otherwise z would be zero or negative)

and from the form of u we conclude that

(10) $2p<11m+2n$ (otherwise u would be zero or negative)

and hence

(11) $46m+10n-400<2p<11m+2n$

Since m, n and p are positive integers, it follows that the first of these three expressions is at least two units less than the second and the second at least one unit less than the third and hence the first is at least three units less than the third, or $46m+10n-400$ is equal to or less than $11m+2n-3$, that is

(12) $35m\leqq 397-8n$

Now the maximum value of $397-8n$ is had by giving n its minimum value, namely 1, therefore

$35m\leqq 389$

(13) or $m\leqq 11\ 4/35$

As m must be an integer it follows that **the maximum value of m is 11.**

Transposing m and n in equation (12) we find that

(14) $8n\leqq 397-35m$

The maximum value of the right-hand member of this inequality is had by putting m equal to 1; hence

(15) $8n\leqq 362$ or $n\leqq 45\frac{1}{4}$

and therefore **the maximum value of n is 45.**

By a similar process we find that **the maximum value of p is 61.**

These results give us also directly the upper limits of x, y and v.

By analogous procedure we can find also the upper limits of z and u, which are 178 and 184 respectively.

It will be noticed that we cannot give all three or even two of the auxiliary constants their maximum values at the same time; in fact when m has its maximum value 11, n must be at its minimum, 1; and when n is at its maximum 45, m must be 1. To get the various individual solutions, we give one of the unknowns, say x, any admissible value; then give n its successive values 1, 2, 3 etc.; for each one of these give p all such values between 1 and 61 inclusive which still keep z and u positive; we then have all the solutions for this particular value of x; then give x another of its admissible values and proceed in the same way as above with n and p. We thus finally get all the solutions of the problem, if we have patience enough.

We will here determine only these solutions in which x has its maximum value 11. Putting m=11 in the expressions for z and u (remembering that in this case n must be put equal to unity) we have

$$z = p - 58 \qquad \text{and } u = 246 - 4p.$$

In order that z may be positive it is necessary to give p only those values which are greater than 58, i.e. p = 59, 60 and 61. And there are therefore only the three following solutions with x = 11:

x =	11,	11,	11	12x =	132,	132,	132
y =	1,	1,	1	3y =	3,	3,	3
z =	1,	2,	3	z =	1,	2,	3
u =	10,	6,	2	u/2 =	5,	3,	1
v =	177,	180,	183	v/3 =	59,	60,	61
Sum	200	200	200		200	200	200

Bachet states that

when x is	11,	10,	9,	8,	7,	6,	5,	4,	3,	2,	1
the number of solution is	3,	60,	200,	388,	571,	704,	832,	911,	977,	985,	1005

Though Bachet's "mathematical procedure" is doubtless infallible, I think that he may have made a numerical slip in applying it: I find the same number of solutions for each of the values of x, except for x = 7, in which case I find only 570 solutions; and for x = 4 for which I find only 903 solutions, making the total 6627 instead of 6639. I would be glad if some one else would figure out these two cases independently so as to have a further confirmation as to the correct numbers.

[I should note here that the above case was not presented in the Meeting of the Association: I have substituted it here both because of its greater historical interest (as it is the first on record, as far as I know) and also because it is simpler than the one I sketched rather hurriedly in our Meeting. I will however here record that one also and give the results of the solution.]

$$x+y+z+u+v = 278$$
$$2x+3y+4z+5u+6v = 1111.$$

General solution:

$x=1+m$	Upper	limit	of	$x=137$;	of $m=136$
$y=1+p$	"	"	"	$y=183$	$n=181$
$z=274-m-n-p$	"	"	"	$z=273$	$p=182$
$u=2-2m+2n-p$	"	"	"	$u\ \ 182$	
$v=\quad 2m-n+p$	"	"	"	$v=137$	

m, n and p may be zero separately, but m and p cannot both be zero at the same time.

The exact number of individual solutions has not yet been determined, but it is approximately 597,000.

Bibliography.

Claude-Gaspar Bachet: Problems plaisants et Délectable qui se font par les Nombres. Cinquieme Edition revue, simplifée et augmentée par A. Labosne.—Paris 1884. Pages 172-179.

J. M. A. Young, Editor: Monographs on topics of Modern Mathematics relative to the elementary field.—New York, 1911. Ch. on the Theory of Numbers.

Encyclopedia Britannica: Art. Diophantus.

N. B. The following work was not available until after the above paper had been read. I find that the method used above is identical with Euler's method.

Leonard Euler: Elements of Algebra, Translated from the French with the Additions of La Grange, and the Notes of the French Translator, in two volumes. Vol. II, Analysis of Indeterminate Quantities. Pages 1-28. London, 1810.

METEOROLOGY

FLYING THE CLIPPER BETWEEN MANILA AND GUAM

Bernard F. Doucette, S. J.

Manila Observatory

On May 22, 1937, I had the pleasure of traveling from Manila to Guam on the China Clipper. On June 3d, the return trip to Manila was taken on board the Philippine Clipper. This privilege was obtained for me by the Pan American meteorologist at Manila, who was practically my classmate at M.I.T., his older brother being one of my instructors there. During his first few months in Manila, I gave him considerable assistance and, as a favor to me, he arranged for the round trip to Guam. Some impressions received during these flights might be of interest to the readers of the Science Bulletin.

Preliminary to every flight, a forecast is made and supplied to the maintenance men, the crew, and the airport manager. Cloudiness, visibility, state of the sea, ceiling and cloud tops have their place in the forecast. The most important items, and the hardest part of the forecast to prepare, are the winds, that is, wind velocity and direction at 4000, 7800, and 11,500 feet aloft. The forecaster makes his estimate of these elements for the three zones into which the flight course is divided. Based upon these estimates, and with the help of special diagrams, the estimated flying time is calculated for those three altitudes. This is the basis for the fuel to be placed in the tanks, a considerable reserve always being added. After the flight, the elapsed time is compared with the estimated time as a check on the forecast, and it is to the credit of my friend that seldom does this difference exceed fifteen minutes, this being for an ocean course of 1585 miles. The cases where the discrepancy was large usually occurred when the Clipper had to detour around some local storm area over the Philippines.

I had often questioned members of the various crews concerning the wind direction and velocities at the altitude of flight they gave with their position reports. The determination of these meteorological elements is intimately bound up with the navigation of the plane, so, on the China Clipper, I had the opportunity to watch the navigator at work. On the way from Manila to Guam, the first two hours, more

or less, there are landmarks on which to sight, excellent for determining the ground speed of the plane. On the other hand, leaving Guam enroute to Manila, the ground speed can not be determined without the help of astronomical observations upon the sun. With the ground speed known, the navigation is quite easy, and dead reckoning methods are quite reliable. For accurate navigation, the wind velocity and direction at the altitude of flight must be known, and it can be determined quite accurately when the ground speed has been calculated. The drift indicator is indispensable for finding the direction of the wind. Another method of measuring drift was the slick made by a flask of aluminum powder dropped upon the ocean waves and sighted with a special alidade mounted alongside one of the windows of the plane. With these helps, the navigator is able to determine his position quite accurately, and, as I found out, the wind direction and velocities which were reported, were not instantaneous observations for a locality but the resultant of the forces acting upon the plane during the previous hour since the last position report. On the China Clipper, the navigator was Mr. Duston Ingram, one of the instructors of the younger navigators, and, with him were three students, or candidates, for the position of navigator in the company. One was navigating the plane under Mr. Ingram's supervision, while the others were "practicing", that is, plotting the positions and having Mr. Ingram check them. Mr. Ingram answered my questions and showed me many things we had talked about before when he visited us at the Observatory. He allowed me to take the bubble octant and sight the sun, obtaining the zenith distance of the same. It was not easy to get the image of the sun in line with that bubble and keep it there long enough to get a good reading of the angle. Six readings are usually taken, within five minutes, for a fix, the best determination of the plane's position. If the clouds do not prevent the navigator from getting his sights, the navigation is easy. When the plane flies under a high overcast layer for some time, and dead reckoning methods have to be the only means of determining the plane's position, it is expected that a change of wind force or direction may occur and cause the plane to fly off course, which could not be known until another fix is obtained. This kind of a situation, far out over the ocean, would require very careful navigating. If the plane were close to the terminal, then the direction finder equipment would be depended upon for obtaining the position. Briefly, the navigator needs astronomical fixes, first, then the direction finder, with dead reckoning methods to be used between the positions. If there are ships along the course, their positions are used to check the navigation of the plane.

The use of the bubble octant is, in principle, the same as that of the sextant. The determination of positions is no different from the methods utilized in marine navigation. On the plane, however, the

computation is much more rapid, tables being used almost exclusively. Many of the navigators on the Pacific division have licenses for third and second officers of the marine service. Considerable marine knowledge and experience is required for operating these ocean going planes, and the candidates have to pass an examination on these subjects before being allowed to join the Clipper crews.

During both of the flights on which I was a passenger, fair weather conditions prevailed, and there were no difficulties for the navigator. At all times, except during the first two hours of the Guam-Manila flight, the sun could be seen and the sights were taken very often. On the way to Guam, I was present when the captain and the navigator discussed the necessity of using high power cruising, in other words, using more power. We had head winds, and it was necessary for the Clipper to reach Guam before sunset, the harbor not being sufficiently lighted for landing at night. Thus, if the plane could not reach Guam in time with the normal cruising power most economical for flying, then the high power cruising would have to be utilized. With strong head winds, and at a high altitude, it requires nice judgement to bring into use this reserve power at the proper time. It means greater gasoline consumption, which must correspond properly with the increased speed to be obtained, in order to reach the destination at the time desired. Normal cruising, I was told, requires about 300 gallons of gasoline per hour, and increased consumption must be carefully watched and the reserve supply checked. It was not necessary to utilize high power cruising on my trips.

I was impressed by the various noises to be heard on board the Clipper. As the plane rises from the water, with rather a heavy load, (speaking of departure from Manila), the drone of the four propellers can be heard for about ten miles. In the air, however, with the pitch of the propellers changed, this sound is not so loud, and cannot be heard such dong distances. In the plane, with the source of such volume nearby, the different sounds are interesting. Up front with the captain, here is no motor noise. Instead, there is a sharp roar, loud enough to make speech difficult, due to the friction of the air upon the hull of the plane. I would compare this sound with the noise caused by a very vigorous sandpapering of the metal. About 12 or 15 feet behind the captain is the flight engineer, in line with the four motors, and getting the benefit of most of their noise. The crew told me that it was easy to go to sleep there, but the many items they had to write concerning the engine operation kept them awake. Phone communication enabled them to report to the captain the various numbers that denoted fuel consumption, oil pressure, and so on. With all the noise, however, the attention of the flight engineer was often easily obtained by a sharp blow with the fist on the hull of the plane. It seemed strange that such a mild sound

could be heard in the midst of the loud volume of noise from the motors. In the passenger cabin, only the subdued drone of the propellers could be heard. The sound-proof material lining the walls very efficiently blanketed out most of the noise associated with the plane. I could not help noticing this when I listened to the members of the crew, who were off duty, entertaining two children, about twelve feet away from me, and every word distinctly audible. In the rear of the passenger compartments, is the baggage and air express compartment, also the rear hatch, where there is no sound proof material. There, the combination of propeller drone, motor exhaust and air friction noises made a deafening roar, which impressed one with the tremendous forces in action. I asked to have the rear hatch opened so that I could see the plane, while flying, from that position, a glorious view indeed.

I was invited up front to see the panorama of clouds and ocean, as well as to see how the plane was flown. I was allowed to sit beside the captain, to look ahead and watch the clouds, to look back at the tireless motors and whirling propellers, to look down upon the small white bits of foam on the ocean waves. It is impossible to describe my sensations there, I only can say that I knew the emotions of the little boys who have been fortunate enough to ride beside the engineer in a locomotive, but I doubt if those little boys knew how I felt. I must speak of the gyro-pilot. This apparatus consists of two gyroscopes, which fly the plane. It is placed in operation about twenty minutes after taking off, and kept that way until about twenty minutes before coming down. During those hours, that compact instrument guides the massive Clipper along the course without requiring any attention to be given to the controls, unless rough flying conditions occur. To see the captain attending to this thing, then another, anything except the rudder and aileron controls, made me realize how far and how well the gyroscope has been utilized in modern air transport. Three knobs on the instrument enable the pilot to make small adjustments in guiding the plane, a turn of the knob deflecting the plane slightly, up or down, right or left, or to either side. Often Captain Lorber would use this means to detour the Clipper around a cumulus nimbus cloud because he did not wish to subject Mr. Summers in the rear compartment to the turbulence in these tropical clouds. (Note: Mr. Summers was suffering from a dislocated vertabra caused by an auto accident.) The crew told me the gyro pilot is excellent in rough flying weather. On the return trip to Manila, there was a long cloud bank, which could not be flown over nor around. Captain LaPorte picked out the lightest part and flew through. It took about a minute and a half, as I estimated, and it seemed to be rough flying. Always was the Clipper on an even keel, often starting to tip sidewise, but never very far. The vertical

motions were rapid enough to give the sensations obtained in an elevator when accelerated, never was there any semblance of diving. One vertical current raised the Clipper up, up, up for about fifteen seconds, and the rate of climb indicator registered two thousand feet a minute, so the captain told me afterwards. Yet, through all of this turbulence, there was no need of using the manual controls, so they told me, but both the captain and first officer had their hands and feet ready to take over the controls. At times, they have to "help" the gyro-pilots, that is, they continue the movement of the controls started by the mechanism. To guide the plane, and such a heavy plane, safely and surely in the smooth open air is quite an accomplishment, and how much more so is the capability of guiding the plane through that turbulence, keeping the craft on an even keel, without excessive rolling or pitching. My short experience made me realize what my aviator friends had been telling me about the turbulence to be expected in tropical clouds and now I understand why they are not anxious to fly blind in the tropics.

The officer on watch in the pilot's place is always testing the synchronization of the propellers. It may not be generally known that this adjustment is made by varying the pitch of the propellers. The gasoline throttle is set for a definite supply of fuel, and then the r.p.m. desired are obtained by changing the pitch using the oil line to the propeller through the axle. Small lights would show the synchronization, and the man on watch seemed to pay more attention to this detail than to any other. On the trip to Guam, number four motor (the extreme starboard motor) began to leak oil. I was up front when the men first noticed it. They called the flight engineer and I waited to see what would happen. He came up to the flight engineer's chair, looked at the dials there, then for about three minutes he stared at that engine. There was no excitement, only a calm study of the situation, most interesting to observe. Nothing was done about the motor however. The oil slowly flowed over the lower wind surface, reaching even the trailing edge, a very messy and uncomfortable sight, yet it did not seem to interfere with the operation of the motor. For about an hour, the motor kept on going, and then a long slow curve to the right made me think that another detour was being made around a cumulus nimbus cloud, but the cloud did not appear. I then noticed that number four engine was shut down, and except for that long curve to the right, there was apparently no change in the flying. About thirty minutes before descending to Apra Harbor at Guam, the motor was started because, as they told me, it was awkward to come down with only three motors. The oil was leaking from the line which led to the propeller blades, and if the motor were allowed to run all the time, they would have lost all of the oil from their reservoir. They had it shut down so that they could use the motor when landing. It was most fascinating to be in front of the plane and look back upon the quiet motor,

with the other three doing all the work, and every thing apparently normal.

On both trips I never tired of looking at the clouds. Many of them were below the flying level, cumulus clouds poised over the ocean. I considered the tall towering cumulus nimbus clouds, brilliantly white, reaching up to twenty-thousand feet, perhaps higher to be the most spectacular. Often the Clipper passed close to them, perhaps two hundred feet away. Even though there appeared to be a sharp surface of demarkation between the cloud and the air, there were many transparent water droplets surrounding the cloud, even at the distance we were. This was evident from the rainbow seen below the plane and above all by the water drops beading off the trailing edges of the struts. Light turbulence was almost always the rule as we approached close to these clouds. It was not a new experience for me to feel a plane quiver and tremble while passing through turbulent air. To be seated by a window as this happens is one thing. It is much different to be standing beside the navigator's table and have the Clipper pass through this turbulent air and then while standing up to feel the plane quiver and tremble.

Concerning clouds and turbulence, I was up front when I noticed a cumulus nimbus cloud directly ahead. The top of the cloud was about three hundred feet above the plane, and it seemed that Captain LaPorte was not going to make any detour. "Are you going through the cloud?" I asked. "Sure" was the reply. "Do you want me to go around?" I didn't. So, standing behind the captain, I braced myself, got a good grip, and waited. We approached that soft white wall, brilliant in the sunlight. Then a sudden splash of water upon the window, and the turbulence began. Up and down, down and up, no sunlight, merely a dull gray color, visibility just out to the end of the wings, many elevator sensations, and in about thirty seconds, out into the clear air again. This was one of the highlights of the trip.

I must not forget to mention the regular distribution of the clouds. This might be called a "lane" effect, as though there were grooves in the atmosphere above the ocean. For about fifteen minutes, the plane would be flying over compact cumulus clouds, so much so that the ocean would be seen only now and then, almost directly downward, glimpses for a few seconds. Then would come a lane. The next fifteen minutes only a few scattered fractus cumulus would be seen, and the deep rich blue of the ocean water would predominate. Then the compact clouds would appear ahead, and so on, throughout the trip. The lanes extended eastnortheast to westsouthwest, the direction of the prevailing winds.

Once in a while at Manila, we would see a peculiar type of cloud, a stratus cloud that seemed to be saturated with dust. Beside a brilliant white cumulus cloud would be this dark gray "dusty"

that there was very little probability of any dust being in the cloud, stratus. With the prevailing winds from the southwest, we knew (in such a case the air would come from the China Sea), and the question was to explain the dark appearance. On both trips, I saw many clouds of this type. I asked the crew what they thought of them and their opinion was that the clouds were in the shade of higher clouds. That is probably true in many cases, but the Clipper flew through one that definitely was no in the shadow of a higher cloud. I could see the dimmed sunshine upon the sponsoon when the Clipper was in the cloud. I would say that the dark aspect of the cloud was due to a form of condensation which did not reflect light as well as the brilliant white cumulus types.

Another interesting sight was the shadow of the plane upon the upper surfaces of cumulus clouds, and the brilliant rainbow around the shadow. This shadow, of course was moving with the plane, and gave us visible evidence of our high speed, about one hundred and fifty miles an hour. The rainbow is "produced by to the primary scattering of the incident light by the directly illuminated droplets of the cloud or fog bank", (Humphreys-Physics of the Air, p 536), known as the Glory and also as the Broken-bow effect. This colored ring rushing with the airplane shadow must be seen to be appreciated; it cannot be described.

At Guam I had a most pleasant visit. I was able to see the locale of the three weather stations on the island, one at the Commercial Pacific Cable Co., under the Philippine Weather Bureau, the observer being an employee of the cable company, the second at the Pan-American airport and the third being the U. S. Navy station. The observations made at these three places often differ, and for a very good reason, being far apart on an island much larger than I expected Guam to be. I stayed with the Capuchin fathers at Agana when no Clipper was at Guam, but when the plane arrived and departed, I lived in the Pan American Hotel at Sumay, where a room was placed at my disposal for the time I would stay at Guam. During the eleven daysI stayed on the island, I obtained a fairly good idea of the conditions that prevailed there, especially valuable were the descriptions of the weather given me by different people. I also realized what were the problems of an airport manager at one of the island stations of the company. Then too, the scenes of the labors and death of Fr. Sanvitores, S.J., the first missionary to live in Guam, were visited. Thus did the time pass until I boarded the Philippine Clipper for Manila, where I again took up the sequence of weather maps at the Observatory.

PHYSICS

POLAROID—THE NEW ARTIFICIAL POLARIZER

Lawrence C. Langguth, S. J.

I. Inadequacy of present polarizing media
II. Polaroid
  a. Aims and Description
  b. Manufacture
  c. Theory of effect
  d. Characteristics
III. Applications
  a. Old, competing with Nicols, etc.
  b. New

Until about two years ago, of the limited number of light-polarizing instruments available, all labored under some serious defect. The plane-glass *reflector*, when set at the proper angle to the incident light, reflected a completely plane-polarized beam, provided that the glass surface was perfectly clean. It presented a large field of view, but the intensity of the light was very low, amounting to only 8% of the incident light. This intensity could be increased by adding the successive reflections from a pile of glass plates, but only to a certain point, since the plates themselves absorbed some of the energy. The light *transmitted* by the same pile was of higher intensity, but was not completely plane-polarized.

Tourmaline, a natural crystal polarizer, exercises such remarkable powers of selective absorption that a slice only one millimeter in thickness suppresses almost perfectly the light vibrations in one plane, but the transmitted light is of such low intensity and colored so deep a green, that the Tourmaline is of little practical value.

The most generally used instrument, the Nicol prism, polarizes almost perfectly and is highly efficient, transmitting between 25% and 40% of the incident light. But the crystal must be more than three times as long as the narrowest width of its face, so that a plane can be cut through it at the proper angle to suppress one of the components by means of total internal reflection, since unlike Tourmaline, calcite does not show a marked difference in absorptive power for the ordinary over the extraordinary ray. This last condition makes it impossible to have a wide-field Nicol, since it is impossible to

find rhombs of calcite large enough. In fact, above a certain average size of perhaps fifteen millimeters aperture they are relatively rare and correspondingly expensive.

Hence the need of some sort of sheet polarizing material, of unlimited area, with no color characteristics, of low absorption coefficient for the transmitted light, and able to be manufactured in large quantities from readily accessible materials.

Such a substance was invented and first patented in 1934 by Edwin H. Land of Boston, now of the Land-Wheelwright Laboratories, and marketed under the name "Polaroid" by The Polaroid Corporation. This artificial polarizer looks and feels like a sheet of heavy cellophane. Like the Nicol and Tourmaline, it makes use of the anisotropic properties of crystals, set in a cellulose matrix and so aligned that their optic axes are parallel, and the effect of the multitude of submiscroscopic crystals is equivalent to that of a single huge polarizing crystal. The substance used is herapathite, a sulfate of iodoquinine. Its formula and a suitable process for its manufacture are given in U. S. Patent No. 1,951,664 issued to Land on March 30, 1934.

He gives the formula of herapathite as:

$$H(C_{20}H_{24}N_2O_2)\cdot 3H_2SO_4\cdot 2HI\cdot I_4H_2O$$

and describes the process:

> "Dissolve 1.5 grams of quinine bisulfate in 50 cc. of methyl alcohol. Bring this solution to a boil and stir, preferably with an iron stirring rod. Remove the heat from the solution and add immediately 0.525 grams of iodine as a 20% solution in alcohol. Continue stirring until a gel forms and until the mass has cooled. The stirring precipitates the periodide of quinine sulfate (herapathite) as a jelly. This jelly comprises colloidal herapathite, probably in the form of needle-like or fibre-like crystals suspended in methyl alcohol."

After the desired crystals are formed, there follows the necessity of combing them out so that they lie all in one direction with their optic axles parallel, and of imbedding them in some sort of matrix to make them maintain that position permanently. The mechanical means of achieving this effect is covered by U. S. Patent No. 1,989,371. The process is one of extrusion.

A layer of the disordered crystals is placed in a compression chamber opposite a long narrow slit aperture, with a large quantity of cellulose acetate or nitrate above and below it. The chamber is compressed, and the crystals are extruded from the horizontal slit in the side wall as a very thin layer between thin layers of the acetate or nitrate. The carefully controlled longitudinal stresses set up by the velocity of extrusion serve to orient the needle crystals with their long axes all in the direction of motion, and once so oriented the sur-

rounding film in which they are imbedded keeps them immobile. The film so formed is cemented between glass plates, merely for mechanical protection and convenience in handling.

Land in the patent specifications says that the crystals occur in two forms, the alpha and the beta, both of which are effective in producing polarization, but not mixed indiscriminately. Because the geometry of each differs, they cannot be used together in the same polarizing film. The crystals are very small, invisible at 1100 magnifications, and must have at least one dimension shorter than the wavelength of the light to be used. And oddly enough, it is found that the film is an effective polarizer even though the concentration of the crystals is relatively low.

In attempting to evolve some theoretical explanation of the effect of Polaroid, the first point to be ascertained would seem to be the crystal system to which the herapathite belongs. Officers of the manufacturing corporation say that the larger crystals, those whose form is observable under the microscope, appear to be of the orthorhombic system, and are biaxial. But those actually used in the films are beyond the range of the microscope, and the manufacturers are unwilling to give a certain opinion with regard to them. It appears that they wish to allow for the possibility of a change in structure, some chemical change.

In behaviour, the Polaroid is more similar to Tourmaline than to the Nicol Prism. Both depend upon the phenomenon of double refraction, or more fundamentally upon the anisotropic property of the respective crystals, inasmuch as the configuration of the atoms and molecules of the crystal structure is such as to transmit much more readily those light vibrations that are in one plane than those in a plane perpendicular to the first. But in the calcite and Nicol, this different ease of transmission manifests itself as a deviation of the extraordinary ray; while in the Tourmaline and Polaroid it operates to completely suppress the ordinary ray, and the crystal layer is so thin that there can be no deviation of the extraordinary ray.

This property of selective absorption, whereby the Polaroid absorbs the energy of the components of all vibrations that lie in a certain defined plane, though seemingly most unusual, nevertheless has a close parallel in the field of color. Color is determined by wavelength, polarization by the direction of the electrostatic and electromagnetic displacements that constitute the electromagnetic wave. A white light, or one consisting of all wavelengths in the visible spectrum, can be colored by transmission if allowed to pass through red glass; the natural resonant frequency of the molecules, atoms, and electrons of the red glass is such that they are set into vibration by all the waves except the red and those close to it, and thus subtract the energy of those other colors, leaving only red. Likewise, an un-

polarized beam of light, or one consisting of displacements in every direction perpendicular to the direction of propagation, can be rendered plane-polarized if allowed to pass through a medium whose molecules, atoms, and electrons can vibrate in resonance with all wavelengths of the incident light, but in one plane only; the components in this plane then of all the heterogeneously directed displacements will have their energy absorbed, and the components in the plane perpendicular to the first will alone be transmitted, thus producing a beam of plane-polarized light.

And just as the absorptive power of the red glass did not reach to all wavelengths, but omitted red, so Polaroid has not the power of absorbing all wavelengths of visible light in the polarizing plane. It is to enable it to absorb as much as possible that the inventor stipulates that the crystals must have at least one dimension shorter than the wavelength of the light to be used. But the polarization is not perfect; it is rated as 99½% perfect. The wavelengths not wholly absorbed are those at the extreme ends of the visible sprectrum, so that with a bright light source and crossed Polaroid plates the light that filters through appears a dim purple, with greater emphasis on the red or violet according as the individual eye is more sensitive to one or other end of the spectrum.

The polarization is claimed to be uniform over the entire surface of the medium, and it is said that the crystals are not affected by ultra-violet light or temperatures up to 250° F., and that they will not deteriorate with age.

Among the uses of the new polarizing medium are some that are old, and some wholly new, in that they make use for the first time of large-area polarizing sheets.

Polarimeters, saccharimeters, and petrographic microscopes are examples of instruments wherein the new Polaroid may possibly displace Nicol prisms. But since the field of view is small, and the new material is not as perfect a polarizer as the old Nicols, it seems more probable that the Nicols will be retained, except in the cheaper instruments.

On the other hand, Polaroid will certainly be used for studies in photoelasticity, where the stresses in mechanical parts are examined by means of xylonite or marblette models, and imperfections in blown or molded glass can be observed directly in a polarizer of large area.

Of greatest interest, however, are the wholly new applications of polarized light made possible by the large area polarizing medium. If automobile headlights be equipped with Polaroid, and drivers are all supplied with Polaroid viewplates, then the direct blinding rays from the lights will be all but invisible, while the light diffusively reflected from the road surface and from roadside objects, its plane of

polarization destroyed, will still penetrate the viewplate and render those objects visible. Higher candle power lights must be used, to make up for the light energy lost in polarization, but the lights may be mounted higher on the car—on the roof, for example—for more efficient illumination of the road surface.

High-gloss paper is difficult to read because of the glare reflected from its mirror-like surface; if the paper be illumined by polarized light and then observed through Polaroid crossed, the glare entirely disappears and the surface becomes a soft mat, restful to the eyes. The same plan can be used in photography to control the amount of specular reflection from highly polished objects, or to eliminate the reflections from the glass walls of showcases and show-windows within which are displays to be photographed. Beauty specialists may employ Polaroid to reduce surface glare and permit more careful study of the true nature of the skin itself.

A novel advertising application is the mounting of a monogram, slogan, or trade mark in cellophane on glass between Polaroids, one or both of which continuously rotate, so that the colors of the design, as seen in the light transmitted from behind, continuously merge into their complementaries.

A very unusual suggestion is the use of Polaroid to obtain cross-court privacy in apartment houses. Windows at opposite sides of apartment courts or air shafts would be fitted with polarizing glass crossed, so that each dweller could look out, but neither could look into the other's apartment—so long as both windows remained closed!

The most striking demonstration given by the manufacturers in their display room is that of three-dimensional motion pictures in full color. In this application, the camera which takes the picture is fitted with a double lens system and prisms, called a "beam-splitter", so constructed as to take simultaneously two pictures of the object from points eye-distance apart, and impress these side by side on common sixteen-millimeter film. Each picture is of course only half as wide as the normal frame. These films are developed as usual with color films, and then run through a projector with the beam splitter in place again. One picture passes through one lens system, the other through the second system, and each system is fitted with a Polaroid plate set with its optic axis at right angles to the other. Two pictures, each of light polarized in opposite directions, fall upon the screen one upon the other, in approximate register, so that to the naked eye there appears to be but one picture, somewhat blurred. But if an aluminized screen be used, so as to reflect the light and at the same time preserve its plane of polarization, and if the spectator wears goggles of crossed Polaroids, each eye will see only one of the two pictures thrown upon the screen, and since each picture is a slightly different view from points eye distance apart, the spectator

forms to himself the illusion of depth. The illusion is thoroughly convincing.

Many of the above applications are suitable for lecture-table demonstration.

A glossy magazine cover may be illumined by a desk lamp in such a way that the glare is reflected directly into the observer's eyes, and the design is invisible in the glare. If then the page is read through a sheet of Polaroid properly held the glare completely disappears and the printing may be seen with ease.

Large Polaroid discs about nine inches or so in diameter, if available, may be mounted vertically about a foot apart in suitable wooden frames so that they can be rotated, and then illuminated from behind by a desk lamp. Beakers, flasks, blocks of unannealed glass, specimens of blown glass such as the bases supporting the electrodes in radio tubes, may then easily be inserted between the plates, examined for strain, and the results made evident to a large class.

If only the smaller discs are at hand, the easiest means of demonstration is by projection. For this purpose the discs may be held in the lens holders of a horizontal optical bench, or a vertical lantern slide projector similar to the one made by the Spencer Company will be found very convenient. The polarizing Polaroid may be laid upon the stage of the projector, with the specimen to be observed on top of it, and the analyzer may be laid upon the upper end of the objective lens. (The manufacturer supplies a cheaper form of Polaroid, diffusing instead of clear and transparent, which will be suitable for the polarizer.)

The usual mica sections show very brilliantly and conveniently with this arrangement, as well as specimens of cellophane and the new adhesive cellophane tape mounted on glass. Glass squeezed in a small vise shows marked coloration where the strain occurs, and Marblette, a new synthetic resin sold by The Marblette Corporation in Long Island City, New York, gives even more brilliant effects. Crystallisations on glass are also very interesting, especially salicine, deposited according to the method explained in Wright's "Optical Projection", Longmans, Chapter XXII, a book that will be found useful in preparing additional demonstrations as well.

PHYSICS LECTURE AND LABORATORY SUGGESTIONS

A Simple Multivibrator: "The Radio Handbook, 1936", page 292. Published by Pacific Radio Publishing Co., Pacific Building, San Francisco, Cal.

A Vacuum Tube Voltmeter: "The Radio Amateur's Handbook, 1936" page 297. Published by American Radio Relay League, Inc., West Hartford, Conn.

Variac, Type 200 *C*. 115 volts, 60 cycles, 5 amperes maximum.
General Radio Company, Cambridge, Mrss.

Thordarson Transformers and Choke Coils.
Electric Manufacturing Company, Chicago, Illinois.
"Apiezon" Products for use in Oil Diffusion Vacuum Pumps, and as sealing media in high vacuum systems.
Technical Products, Ltd., England. (James G. Biddle Co., 1211 Arch St., Philadelphia, Penn.)
A Line Source of Light: "General Electric Mazda, 1000 L., 6.6 A."
For metal parts of a vacuum system: "Glyptal Lacquer".
General Electric Company.
"Duco Household Cement": E. T. Du Pont de Nemours & Co., Wilmington, Del.
Scotch Cellulose Mending Tape: Minnesota Mining and Mfg. Co.. St. Paul, Minnesota

T. H. QUIGLEY, S.J.

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Part I —This Bulletin, March 1937, pp. 138-142.
Part II —This Bulletin, May 1937, pp. 193-198.
Part III—This Bulletin, December 1937, pp. 83-84.

FRENCH PUBLICATIONS (continued)

The following works are published by HERMANN & Cie., 6 Rue de la Sorbonne, Paris, France.
Actualitiés Scientifiques et Industrielles (A series of excellent brochures on mathematics and science. Up to date 514 brochures have been published. We list below some of the more important items for the B.S. Physics Reference Library).

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325.	C. Platrier: Cinématique de Solide et Théorie des Vecteurs	12 fr.
326.	C. Platrier: La Masse en Cinématique et Théorie des Tenseurs du Second ordre	18 fr.
327.	C. Platrier: Cinématique des Milieux continus	8 fr.
332.	M. Nahmias: Analyse des matières cristallisées au moyens des rayons X	15 fr.
333.	E. Goursat: Propriétés generales de l'equation d'Euler et de Gauss	20 fr.
336.	G. Boutry: Les phénomènes photoélectriques (III)	20 fr.
337.	G. Boutry: Les phénomènes photoélectriques (IV)	15 fr.
340.	Congrès International de Physique I. Les rayons cosmiques	10 fr.
341.	C.I.P. II. Transmutations	18 fr.
342.	C.I.P. III. L'état solide de la matière	18 fr.
344.	E. Darmois: Le deutérium, 2e partie	10 fr.
345.	G. Boutry: Les phénomènes photoélectriques (V)	15 fr.
346.	G. Boutry: Les phénomènes photoélectriques (VI)	15 fr.
347.	B. Brajnikov: Pétrographie et rayons X	12 fr.
356.	G. Darmois: L'emploi des observations statistiques	10 fr.
369.	G. Gamow: Cinétique des réactions nucléaires	8 fr.
378.	P. Humbert: L'oeuvre astronomique de Gassendi	8 fr.
399.	R. Freymann: Les ondes hertziennes et la structure moléculaire (I)	10 fr.
400.	R. Freymann: Les ondes hertziennes et la structure moléculaire (II)	15 fr.
411.	L. de Broglie: Une nouvelle conception de la lumiére	12 fr.
427.	C. Platrier: Les axiomes de la mécanique newtonienne	14 fr.
436.	R. de Possel: Sur la théorie mathématique des jeux de hasard	10 fr.

SERIE 1937:

457.	J. Brillouin: L'Acoustique et la construction (I)	18 fr.
458.	F. London: Une conception nouvelle de la supraconductibilité	20 fr.
463.	G. Castelnuovo: Probabilites dans les differentes branches de la science	12 fr.
471.	M. Arcay: Les ultrasons et leurs applications	15 fr.
479.	A. Sesmat: Le problème	**12 fr.**
480.	A. Sesmat: L'ancienne astronomie d'Eudoxe à Descartes	15 fr.
481.	A. Sesmat: Mécanique newtonienne et gravitation	20 fr.
482.	A. Sesmat: Le système absolu de la mécanique	8 fr.
483.	A. Sesmat: L'optique des corps au repos	18 fr.
484.	A. Sesmat: L'optique des corps en mouvement	20 fr.
485.	A. Sesmat: L'esprit de la science classique	12 fr.
486.	A. Sesmat: Genèse des théories de la relativité	10 fr.
487.	A. Sesmat: Principes de la théorie restreinte	12 fr.
488.	A. Sesmat: Les systèmes privilégiés de la théorie restriente	12 fr.
489.	A. Sesmat: Principes de la théorie générale	12 fr.
490.	A. Sesmat: Théorie relativiste de la gravitation	15 fr.
491.	A. Sesmat: Les systèmes privilégiés de la théorie générale	5 fr.
492.	A. Sesmat: Essai critique sur la doctrine relativiste	10 fr.
493.	R. Lambert: Structure générale des nomogrammes	15 fr.

SEISMOLOGY

LOWER LAKES REGION LAND-TILT

Rev. John P. Delaney, S.J.

(Abstract of paper presented at the National Academy of Sciences at a meeting of the American Geophysical Union.)

This brief note is presented as a progress report on the project of measuring seismographically the very slow land-tilting that has been known to affect the lower lakes region.

Previous papers have reviewed the work of Gilbert, Sherman, Moore, and Gutenberg on this subject, and have discussed also the inherent tilt sensitivities of certain types of horizontal seismometers and their precision in the measurement of very slow and almost infinitesimal tilting. (1, 2, 3)

The Wiechert seismometer at Buffalo has given evidence for a number of years of a very slow southwesterly tilting, precisely the direction of tilting found by Gilbert on geological evidence and by Moore from the data of the water-gage records of the Great Lakes.

The cumbersome Wiechert could not be relied upon for precise measurement of this tilting, since the instrument is disturbed every day in the process of changing records. So a long period Wood-Anderson seismometer was set apart three years ago for this purpose. It was orientated north-east and south-west, adjusted to a twelve second period, completely sealed in a celotex cabinet, the only opening for the light beam being sealed with a lens. The instrument was to be left severely alone and undisturbed for the sole observation of the shift in its zero line under the influence of ground tilting.

Three various types of ground tilting have been observed: 1) Small and irregular tilts definitely associated with barometric gradients; 2) an annual tilting toward the northeast in winter and toward the southwest in summer; 3) a very slow but continuous tilting toward the southwest.

This progressive southwest tilting was measured between the winters 1935-1936 and 1936-1937. In the course of the year the average position of the light spot was found to have shifted several inches,

indicated an accumulated tilt in the course of the year of the order of 0.7 second of arc.

(1) Delaney—Seismographic Sensitivity to Tilt—Proceedings Geological Society of America, 1934.

(2) Delaney—Seismographis Tilt Recording—Earthquake Notes, vol. 7, 1.

(3) Delaney—Seismographic Tilt Measurements at Buffalo—Transactions American Geophysical Union, National Research Council, 1936.

NOTES

REV. JOSEPH GIANFRANCESCHI AND THE PONTIFICAL ACADEMY OF SCIENCES

In the BULLETIN for March, 1937 (Vol. XIV, pp. 104-109) there was published an account of the newly organized Pontifical Academy of Science. In SCIENCE for November 19, 1937, (Vol. 86, No. 2238, pp. 470-472) there is a similar account, with the addition of a very interesting description of the first solemn inaugural meeting of the Academy which was held on May 31, 1937, the Pope's birthday. In both these articles a passing mention is made of the part taken by Father Joseph Gianfranceschi, S. J., in the reorganization of the older Accademia dei Nuovi Lincei which terminated in the establishment of the new Academy. Further details of Fr. Gianfranceschi's part in this work was given by His Holiness in the Solemn Meeting of the older Academy held on January 12, 1936; His Holiness's address was reported in L'Osservatore Romano in its issue of January 13-14, 1936. The following abriged translation of the address was made by Mr. Joseph F. Costanzo, S. J., of Woodstock College, from the reprint which may be found in the Acta Romana S. J., for the year 1936 (Vol. VIII, Fasc. 2, pp. 446-448), and will doubtless be of interest to the readers of the BULLETIN:

"The Holy Father received the new president of the Pontifical Academy of Sciences. The ceremony called to mind the memory of his predecessor, the deceased president, the beloved Father Gianfranceschi who was so widely honored and esteemed not only by all the members of the Academy, but also by the world of scholars who appreciate what serious study is. It was not only the honored and cherished memory of Father Gianfranceschi that His Holiness wished to evoke. He believed the time had come to reap the intellectual heritage the devout religious had left by his assiduous and continued labors for the Pontifical Academy of Sciences.

Frequently in his lifetime, Father Gianfranceschi confided to His Holiness by word and by writing his many paternal ambitions for the Academy, his plans for it, the development and formation of it according to those ideals of science and scientific culture which animated his whole spirit. His aspirations rose high. He began by asking for the more spacious and comfortable assembly hall of the Academy. "Beautiful and exquisite", as Father Gemelli described the

Casina of Pius IV., it was in truth too narrow for the conveniences of the Academy, so that it was properly said of it, "dilatentur spatia veritatis (si non caritatis)". His Holiness immediately recalled that desire which he had clearly cherished as his own and that of his beloved servant, Father Gianfranceschi. The design and structure of the present hall of the Academy is without doubt the fulfillment of the foremost thought and desire of the deceased religious. But the aspirations of Father Gianfranceschi went further. He studied with particular care and with all delicacy that the consideration required a more renowned membership of scientists for the Academy. His Holiness was greatly pleased with Father Gianfranceschi's plans and just as the Holy Father had sought to satisfy the first desires of the deceased father, so also now in counsel and deliberation with the new president has he attended to this more important particular—the membership roll of the Academy. The August Pontiff was happy to say that with the assistance of Divine Providence and the good-will of men the fulfillment of these plans was not far away. It will be the office of the new president with the ready assistance of the Holy Father to labor for this important arrangement and thus give the last touching hand to the restoration of the Pontifical Academy. Without doubt, it will be a difficult task, but all is possible of attainment to those of good-will. Again it will be the office of the new president to announce in no ordinary way the convocation of the Academy for next February".

J.F.C.

GERMAN SCIENCE CHATS

At once popular, as well as German and scientific are two books published by the Bonner Buchgemeinde (similar to our "Book Clubs") which have come to the writer's attention.

"Chemische Plauderein" by Robert Wizinger (Verlag der Buchgemeinde/Bonn, 1936, circa RM. 6.00) contains all in the line of "chemistry chats" that its title promises. For the teacher of general chemistry, the book should prove of great value. Of even greater value is it to the teacher of chemical German, who might recommend it to his students as a humane introduction to the course. For houses of "ours" where the latter course is left much more to the initiative of the individual, a painless preface not only to chemical German but to German chemistry as well, may be found in the chats.

What has been said of the "chemistry chats" may be repeated for the "physics chats",—mutatis mutandis. This companion volume: "Physikalische Plaudereien" by Heinrich Konen appeared in 1937 from the same firm and sells at RM. 5.40.

In addition, this second volume solicits the interest of the natural philosopher. For in it, the discussion of the formal and material objects of the various sciences is well conducted, even though incomplete perhaps, and without the scholastic terminology.

The chapters on space, time, measure and energy start gently from a philosophic background, touch lightly on a few historical landmarks of physics, expose clearly the modern physical viewpoint, and soon conclude in modern technical applications.

Konen, the author, is said to have been a very successful professor at Bonn who is now retired (!). He is also said to be a good Catholic residing at Bad Godesberg on the Rhine. But his philosophical backgrounds are generally non-committal, a theory of Kant or Leibnitz usually constituting the philosophical preface to a given topic. One short Jesuit biography appears in the biographical appendix,—that of Fr. Caspar Schott. Einstein, mentioned in the text, finds no place in the biographical appendix. On the other hand, Adolf von Harnack rates four centimeters of biographical material. Very Reverend Fr. Theodore Wulf, said to be a good friend of the writer, though not explicitly mentioned in the text finds in it a modest place through the Wulfsche Elektrometer.

In the "physics chats" the illustrations are profuse and scattered through the text. Much of the illustrative material is borrowed from the Deutsches Museum in Munich. In the "chemistry chats", the illustrations are fewer and come by way of appendix. "Physics chats" has gone much further in presenting physics as a unified science than its companion has done for the unification of chemistry.

In these days one finds many low-priced popular science books in Germany. These two however are a bit costlier and stand out above the rest. In the writer's opinion, they will go a long way to sweep the translation of our American popular classics out of the German market.

Bernard A. Fiekers, S.J.,
Jgnatiuskolleg,
Valkenburg, (L.),
Holland.

NEWS ITEMS

NATIONAL MEETING OF JESUIT SCIENTISTS

The third annual meeting of the National Association of Jesuit Scientists was held on December 29, 1937, at the Cathedral School, Indianapolis, Indiana. Representatives of five provinces attended the meeting: New England Province, Maryland-New York Province, New Orleans Province, Missouri Province and Chicago Province.

The presiding officer was Rev. Richard B. Schmitt, S.J., Loyola College, Baltimore, Maryland, assisted by the secretary, Rev. Emeran J. Kolkmeyer, S.J., Georgetown University, Washington, D. C.

The topics for discussion included:

Report on the Science Conventions of the various provincees during the year.

Report on the Research Work in our colleges and universities.

National Science Convention as part of the Centenary Celebration a) Committee for general plans; b) Committee for program of sectional meetings.

The History of Science in the American Assistancy for the Centenary Number of the Bulletin of the A.A.J.S.

National Science Bulletin.

An exhibit in the New York World's Fair.

Copies of the minutes of this meeting were mailed to the Reverend Fathers Provincial, and to the Reverend Rectors of the colleges and universities in the United States, through the office of the National Secretary of Jesuit Education.

At the election of officers, Father Schmitt and Father Kolkmeyer were again chosen to preside at the next meeting in Richmond, Virginia.

MARQUETTE UNIVERSITY

At the annual Science Exhibition of the American Association for the Advancement of Science meeting at Indianapolis, Indiana, December 27 to 31, the Biology Department had a booth in which they displayed the Fresh-water Sponges of Wisconsin. Complete specimens of eleven species were exhibited; spicules and gemmules of representative species were mounted for inspection under eleven microscopes. A sectional map of Wisconsin showed the regions from which the sponges were taken; colored photographs represented the sponges

in the natural habitat; camera lucida drawings afforded an exact reproduction of internal structure and organization. Leaflets were distributed describing in detail the various parts of the exhibit.

The Marquette Zoological Society is in its tenth year. Some forty students mainly from the College of Liberal Arts and the School of Nursing with a few from the College of Journalism and the College of Business Administration are members of the society. The program for the year is prepared by the students under the direction of a faculty moderator. The program for 1937-38 bears the picture of Father Wasmann with the inscription: Eric Wasmann, S.J., 1859-1930, Entomologist, Writer, Lecturer.

Eight formal meetings are held during the scholastic year, and two field trips. Some of the speakers for this year include: Rev. J. F. Carroll, S.J., Dr. A. J. Quick, Rev. F. A. Bautsch, S.J., and Dr. W. N. Steil.

MANILA OBSERVATORY, Philippine Islands

Rev. Charles E. Deppermann recently published another monograph, entitled: Are There Warm Sectors in Philippine Typhoons? It is an official publication of the Manila Central Observatory of the Weather Bureau of the Commonwealth of the Philippines, Department of Agriculture and Commerce. This publication is a part of the research program of the Manila Observatory.

Other monographs by Rev. Charles E. Deppermann, S.J., Assistant Director of the Philippine Weather Bureau include:

1. Mean Transport of Air in the Indian and South Pacific Oceans. 1935.
2. Outlines of Philippine Frontology. 1936.
3. The Upper Air at Manila. 1936.
4. Wind and Rainfall Distribution in Selected Philippine Typhoons. 1937.
5. The Weather and Clouds of Manila. 1937.
6. Temperature Conditions in the Eye of Some Typhoons. 1937.
7. Are There Warm Sectors in Philippine Typhoons? 1937.

LOYOLA COLLEGE, Baltimore, Maryland

Chemistry Department—

On Thursday, February 24th, Rev. Richard B. Schmitt lectured to the members of The American International Academy, on the subject: "Micro Organic Analysis."

The first meeting of the second semester of the Loyola Chemists' Club assembled on Monday, February 14th in the Chemistry Lecture-hall to hear a lecture delivered by Dr. Herbert Insley, Petrographer from the National Bureau of Standards, Washington, D. C. The

topic under discussion was: "The Constitution of Portland Cement." The lecture was illustrated with micro slides projected with our Zeiss micro-projector.

FORDHAM UNIVERSITY

Physics Department—

Dr. William A. Lynch (Ph.D., New York University), joined the Physics Faculty in September 1937 as Professor of Physics.

Fordham University headed the list of hosts at the convention of the New York and New England geological societies October 25 and 26, 1937. A large group visited the geophysics laboratory and the seismic station; Dr. W. A. Lynch lectured to them on the operation of the apparatus and the interpretation of the records and conducted them through the station.

Rev. J. Joseph Lynch lectured at the Hayden Planetarium on January 19 to the Amateur Astronomers' Association on *Modern Seismology.* A large and enthusiastic audience attended.

A list of local shocks in the New York area was published in *Earthquake Notes* for December 1937. These had been detected by the vertical Benioff seismometer which was put in active service early in September. The report covered local quakes from September 5 to November 27.

Dr. W. A. Lynch addressed the Science Club of the College of Mount Saint Vincent on January 17 on the general subject of earthquakes. He illustrated his remarks with simple demonstrations and lantern slides.

GEORGETOWN UNIVERSITY

Chemistry Department—

Fellowships—This year four graduate fellowships in Chemistry were granted.

Graduate Chemistry Library—The third floor Student Lounge in the White-Gravenor has been made over into a Graduate Chemistry Reference Library. Practically all of the Journals of use in the work undertaken in the Graduate Chemistry courses have been acquired. Complete sets of these journals are now available on the campus for those taking degree work.

Increase in Numbers—The Graduate courses now given have attracted many to the Chemistry Department of our Graduate School. There are seventeen enrolled in the various courses. Beside the Fellows in Chemistry there are a few men from Government Departments (Agriculture, Soils, etc.) working towards the M.S. and Ph.D. degrees.

Graduate Seminars since September 1937.

1. The Effect of Aldehyde and Ketones on the Estimation of Cystine and Cysteine.—W. C. Hess, Ph.D.
2. Specific Precipitation and Colorimetric Tests for the Guanidine Filed—asymetrical dimethyl guanidine.—Filedelfo Irreverre.
3. Test for Creatine and Creatinine.—John T. Mountain, M.S., Candid. Ph.D.
4. Progress Report on Specific Tests for Ceatine and Asymetrical dimethyl Guanidine.—M. X. Sullivan, Ph.D.
5. Sulfanilamide—Dr. Ralph Mellon. (Western Pennsylvania Hospital, Pittsburgh--Branch of Mellon Institute.)
6. Tryptophane and Cystine Test of Sera.—H. S. Milone, Ph.D. (Georgetown Med. School Professor.)
7. Biochemical Studies of Tryptophane Molds. Fungicidal and Bacteriacidal Action of Certain Organic Sulfur Compounds. —E. L. Everett, Ph. D. (Geo. Med. School Prof.)
8. Chemical Aspect of Allergies.—E. J. Coulson (Dept. Agriculture.)
9. Papain.—S. P. Hoover (Dept. Agriculture.)
10. Determination of Vitamin A.—J. B. Wilkie (Agriculture Dept.)
11. Selenium Intoxication and Selenium Homologues of Sulfur.—F. P. Wilson, M.S., Candid. Ph.D.
12. Iodine in Blood and Urine.—A. F. St. Andre, Graduate Fellow, Candid. Ph.D.

Medical School—

Assisting the Board of Health of the District of Columbia in its fight against preventible diseases, the Medical School, on January 20th, presented Dr. Royal S. Copeland, United States Senator from New York, as the speaker at the first of a series of eight weekly Public Health Forums. The entire program of forums has been shaped to give the average layman a practical, non-technical knowledge of the possibility of preventing a disease. Many outstanding medical authorities, including such notables as Dom Verner Moore, O.S.B., M.D., of Catholic University and Dr. Morris Fishbien, Editor of the A.M.A. Journal, have been selected as lecturers in the series.

BOSTON COLLEGE

Science and Philosophy—

The New England Chapter of the Catholic Round Table of Science held its fifth meeting at St. Joseph College, West Hartford, Conn., December 4, 1937. Rev. John A. Tobin, S.J., Prof. Physics, Boston College, Boston, Mass., presided. The Chapter chose for its

discussion: "Concepts in the Physical and Metaphysical Sciences."

"Concepts in Metaphysics".

Rev. Joseph P. Kelly, S.J., Prof. Cosmology, Weston College, Weston, Mass.

"Concepts in Chemistry".

Sr. M. Concilia, Prof. Chemistry, St. Joseph College, West Hartford, Conn.

"Concepts in Physics".

Dr. Fred. White, Prof. Physics, Boston College, Boston, Mass.

Dr. Dunleavey of Yale University addressed the assembly on research work in Colleges and Universities.

On December 11, 1937, the New York Chapter met at Fordham University, Fordham, N. Y., for the winter session. Rev. F. P. LeBuffe, S.J., presided. Rev. Joseph P. Kelly, S.J., treated the problem of: "Scientific Predictability", from a philosophical point of view. In both meetings lively discussion followed the reading of papers. These discussions and the numerous questions proposed show an increasing interest in topics which are common to both scientists and philosophers.

Chemistry Department—

A new course given at Boston College this year and to be offered also at the summer session, is designed as an introductory course for the senior Pre-medical students to their future work in Medical School. Although termed Bio-chemistry a better designation would probably be Pre-medical Chemistry.

Heretofore the pre-medical students at Boston College were required to take Organic Chemistry and Inorganic Chemistry only. But, since success in Bio-chemistry in Medical Schools is in a great measure dependent on the students' knowledge of Quantitative, Colloidal and Physical Chemistry, this new course has been introduced to meet the students' future needs. The material covered in the various fields mentioned above is of necessity limited, but the topics emphasized are those which, from the experience of the Pre-medical Chemistry Professor as an Instructor in Medical School and from the suggestions offered by professors in local Medical Colleges, are believed to be fundamental for a sound working knowledge of Physiological Chemistry.

The laboratory work is designed to familiarize the student with analytical technique as presented in the various Colleges of Medicine. No attempt is made to carry out the various analytical procedures in blood analysis, but a thorough grounding in Volumetric and Colorimetric methods is given.

It is felt that the course will prove its value most strongly in facilitating the transition from Pre-medical to Medical work in Chemistry, in enabling the student to cope with the problems of Medical School Bio-chemistry, and in obviating the period of adjustment that

too often has hindered the first year medical student. From past experience the course will have justified itself, if these things are accomplished.

Mathematics Department—

There are three hundred and fifty-two undergraduates enrolled in the various courses of Mathematics. A lively interest in Mathematics is more in evidence this year than ever before.

Recently at the request of many of the students a Mathematics Academy was organized. At the first meeting, held recently, thirty-one prospective members were present. Anthony J. Eiardi, S.J., is the moderator of the Academy. At the first meeting Fr. O'Donnell outlined the fields of Mathematics, pointing out the new fields still awaiting exploration and indicating the cultural as well as the practical values to be derived from the study of Mathematics.

Mr. Eiardi has arranged an excellent tentative schedule of topics to be discussed at the meetings of the Academy. Fuller details and reports of these meetings will be published later.

There are fourteen graduate students taking the advanced courses this year. They are taking courses in the Functions of a Complex Variable, Vectorial Geometry, Analytic Geometry of Space, and the Theory of Probability.

The Mathematics Library is now situated in a room on the first floor of the Science building. In all it contains about three thousand volumes. The branch of Analysis is especially well equipped. A distinctive feature of the Library is its fine collection of periodicals. The chief American Periodicals are to be found here practically complete, as well as the complete sets of the London Mathematical Society publications and the Bulletin de la Societé Mathematique de France. The set of the Encyklopadie der Mathematischen Wissenschaften was recently completed.

WESTON COLLEGE

Department of Physics—

Fr. Thomas Smith, who took his M.S. at Georgetown last year, is teaching the first year Physics and is assisting in the Seismological Observatory. He is also directing an Academy composed of a small group of theologians and is taking a course at M. I. T. Fr. H. Brock is teaching the more advanced class open to second and third year philosophers. It follows a two year cycle, this year being devoted to electricity and magnetism. In November the class accepted an invitation to visit the Waltham Exchange of the Bell Telephone Company. Last May the class visited the Boston factory of C. L. Berger & Sons, makers of surveying and engineering instruments. Among additions to the equipment the past several years mention

may be made of the following: a Leeds & Northrup Precision Wheatstone Bridge, R.C.A. Cathode Ray Oscillograph, Cenco Hysteresis apparatus, Cenco M/H magnetometer, Hanovia Quartz mercury lamp, General Radio Variac Transformer, G. M. Power Supply Unit, Thordarson Induction Coil, six volt used Edison Battery, Cenco Thermoelectric Magnet, used X-Ray outfit, Milvay string vibrator, G.E Light meter, Cenco Stop clock, a moving picture projector with sound attachment.

Father Joseph P. Kelly is giving a course on Science and Philosophy at the Boston College Graduate School.

Seismological Observatory—

Numbers 5, 6, and 7 of the Station Bulletin have been published. On Tuesday, November 20th, Father Linehan gave a lecture on Seismology to the Rotary Club of Southbridge, Mass. On January 17th, he spoke before the faculty and students of Worcester Polytechnic Institute. Mr. Devlin, S.J., completed his analysis of the Benioff transducer and Mr. Shea has completely overhauled the Bosch-Omori and Wiechert instruments and remodeled the time marking system. A notable increase in sensitivity has resulted.

The proceeds from the premiere showing, in a Boston theatre, of the motion-picture film, "Monastery", in which Father Ahern acts as narrator, went toward establishing a fund to be used in the interests of Seismology at Weston.

ST. LOUIS UNIVERSITY

Medical School—

On the occasion of the installation of Dr. Rufus C. Harris as president of Tulane University, Father Alphonse M. Schwitalla, Dean of the School of Medicine of St. Louis University, received the Doctorate of Humane Letters.

GONZAGA UNIVERSITY

Science Department—

On January 28th the contract for the Coulee High Dam was awarded. This structure will be the world's largest electrical generating plant, as a consequence the Northwest is becoming decidedly electricity-minded. The anticipated awarding of the contract resulted in a large registration in the Electrical Engineering classes at the University.

Rumor has it that the engineering staff of the University has "just around the corner" of the lab the Northwest's first television transmitter. If and when completed experimentation will be carried on between transmitter in the basement and receiver on the first floor.

New courses added this year include Mr. Nixon's course in Thermodynamics and Mr. O'Rourke's courses in Histology and Microtechnique.